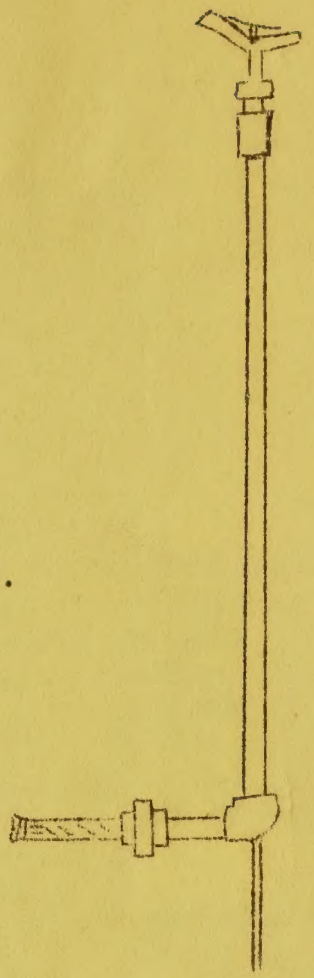
GARDEN WATERING



SELECTION OF NOZZLE SIZE

CALCULATING PRESSURE LOSS IN PIPES ETC.

CALCULATING PUMP PRESSURE

HOW TO APPLY WATER

MAKE THE GARDEN PAY WITH

YOUR HOME ELECTRIC WATER SYSTEM

RURAL ELECTRIFICATION ADMINISTRATION
U. S. DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

ELECTRO-ECONOMY SERIES #1

INTRODUCTION

It is generally accepted that the watering of the farm garden will increase both the quantity and the quality of the vegetables produced. Many bulletins and articles have been written on the subject of garden watering and its benefits, but little information is available on the matter of the mechanics involved in applying the water to the garden. In this publication an attempt has been made to describe briefly and in the simplest possible terms the mechanics and hydraulics of garden sprinkling with the home electric water system.

Many sprinklers are now on the market, but no attempt has been made to consider the adaptability of all of the sprinklers available for garden watering. The characteristics described in the following examples, and shown in the accompanying tables and charts pertain to one sprinkler that has certain characteristics essential to garden watering. Among the more important of these characteristics are low first cost and a desirable distribution pattern. Several other sprinklers are equally well adapted from the water distribution standpoint, and much of what is written herein could be applied successfully to those sprinklers.

Selection of Nozzle Sizes

Considerable variation in the discharge of the type of rotating sprinkler shown in Figure 1 can be effected by a change of nozzle size. Table 1 shows the relation between nozzle size and sprinkler discharge when operating within a practical pressure range. The same relationship has been graphically represented on Chart No. 1. Since pressure loss due to friction in the hose or pipe between the pump and the sprinkler plus the pressure at the sprinkler represent pressure at the pump, it is desirable that the sprinkler pressure be less than the pump cut-off pressure. When the cut-off pressure is exceeded, the continual stopping and starting of the pump will interfere with the successful performance of the sprinkler, will cause excessive wear and tear on equipment and will increase the cost of applying the water.

Pressure Drop in Pipe and Hose

When water flows through a pipe or a hose it encounters resistance, the magnitude of which depends on the roughness of the inner wall of the pipe. The resistance thus encountered is usually called friction loss and will be referred to from time to time in this publication as loss of head due to friction. Tables 2 to 7, inclusive, indicate the pressure drop in lengths of pipe and hose when different quantities of water are flowing, while Table 8 has been included to represent the loss of pressure in faucets, elbows, and other pipe fittings.

The values of pressure drop shown in the tables should be considered as an approximation. They do serve, however, as a guide in estimating the loss of pressure that may be expected when water is forced through iron pipe or garden hose.

Applying the Water

Garden crops require approximately one inch of water each week for satisfactory growth in summer months. During dry spells, therefore, garden watering can be employed to supply the plants with this required moisture. It is commonly accepted that the necessary inch of water should, if possible, be put on in one application rather than in a number of light sprinklings. Chart II, as well as Table 1, show the time required to apply one inch of water to the area covered in one setting of the sprinkler.

Distribution characteristics of many rotary sprinklers indicate that about ninety per cent of the water discharged falls within a circular area equal to about fifty per cent of the actual area covered by the spray. Within this inner circle the ninety per cent of the sprinkler discharge is fairly evenly distributed. In computing the time required to apply one inch of water in one setting of the sprinkler, the area covered effectively was taken as fifty per cent of the total area covered, while the water applied was considered as ninety per cent of the pump capacity.

Because of the tapering off of the quantity of water falling near the outer edge of the circle covered by the sprinkler, it is desirable that spacing between sprinkler settings does not exceed fifty or fifty-five feet, even though the diameter of the circle covered is seventy-five or eighty feet.

Electrically Operated Water System and Garden Watering

The electrically operated farm water system lends itself favorably to watering of the garden during night hours. In the night the water requirements in the home and about the farm are least, and the entire capacity of the pump can be applied to the garden. Where the discharge of the sprinkler is comparatively small, all night operation becomes a practical possibility. If the pump capacity is such that only a few hours of operation of one sprinkler is necessary to apply the necessary water, two or more sprinklers, fitted with the correct nozzle sizes, can be used so that all-night operation will be possible.

Power Required to Operate the Pump

Chart III has been included as a simple means of determining the power required for operating electric water systems. Since cost per kilowatt-hour varies somewhat in various sections of the country, energy required per hour rather than cost per hour of operation has been plotted against total operating head. The graphs represent only the capacities of the three pumps used as examples throughout. Lines representing other pump capacities can be sketched in between the existing graphs.

Total head consists of:

1. Lift in feet, the vertical distance from the water-level in the well, when pumping, to the gauge at the pressure tank.

2. Pressure head in pounds per square inch as indicated on the gauge at the tank. Convert pounds per square inch to feet of head by multiplying the gauge reading by 2.31.

Using the Charts and Tables

In the following pages examples are shown to clarify the descriptive matter and to show the use of the charts and tables. Although the charts and tables have been extended over a considerable range of pump capacities, the following examples are confined to the more common water system capacities of 200-, 275-, and 400-gallons per hour.

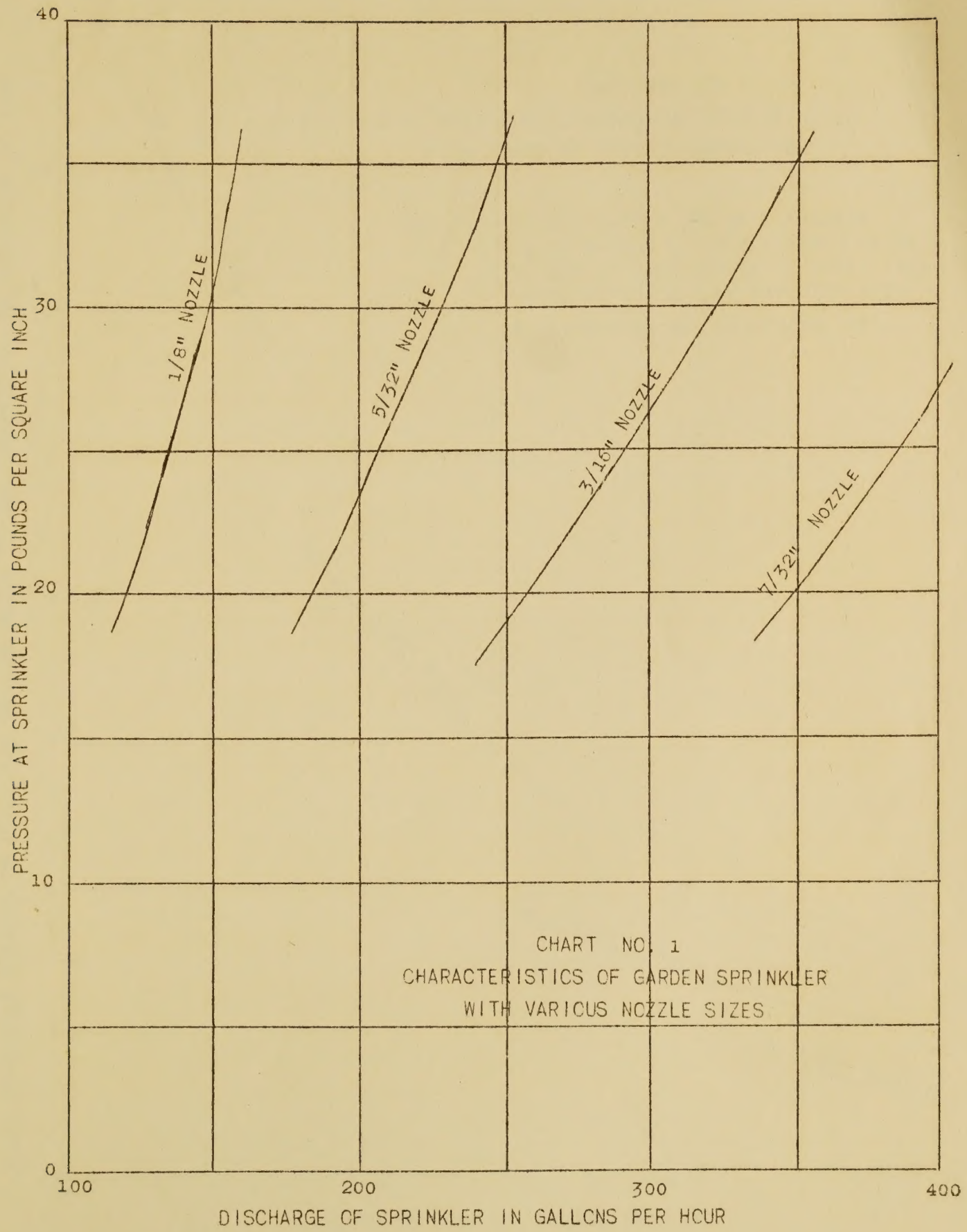
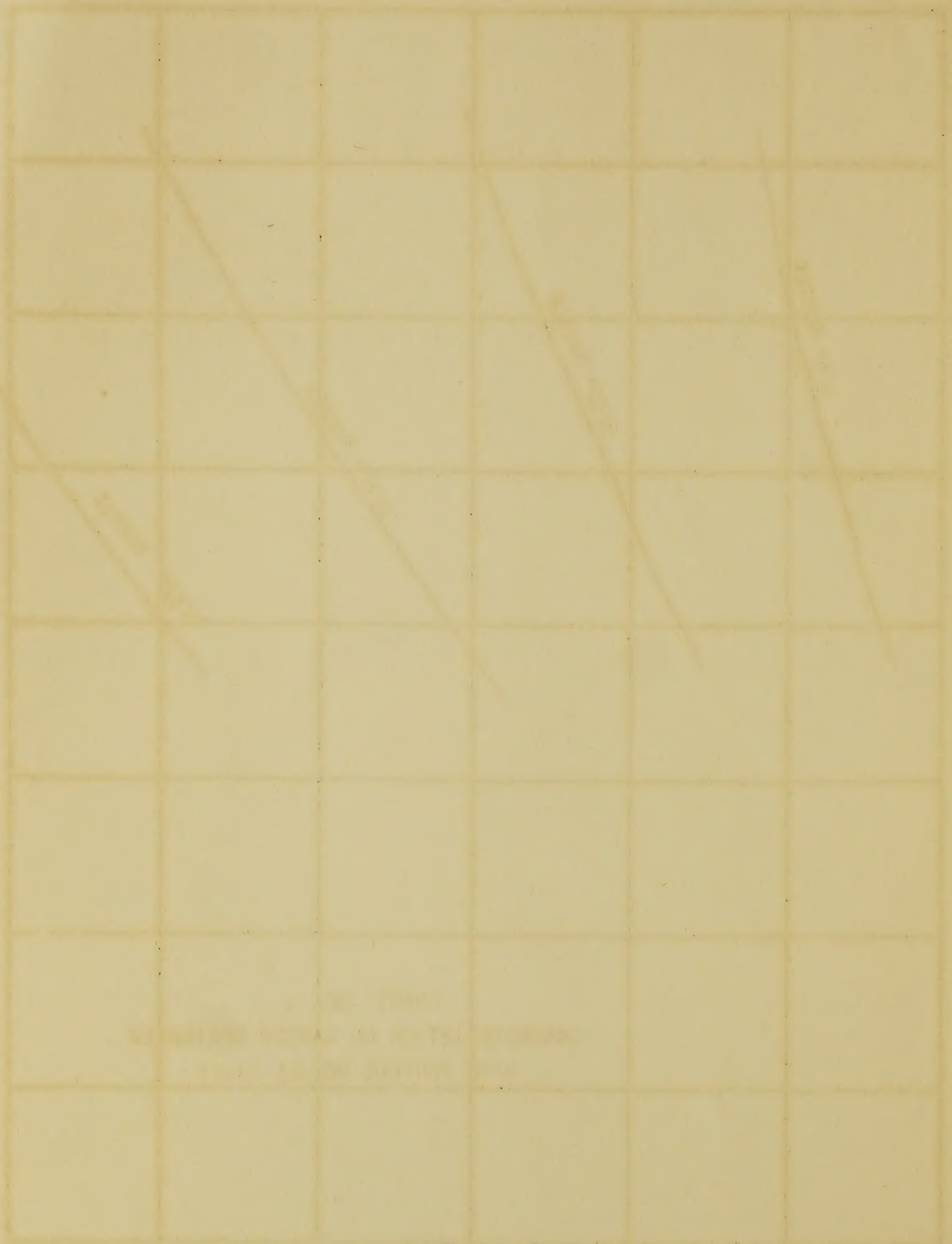


CHART NO. 1

CHARACTERISTICS OF GARDEN SPRINKLER

WITH VARIOUS NOZZLE SIZES



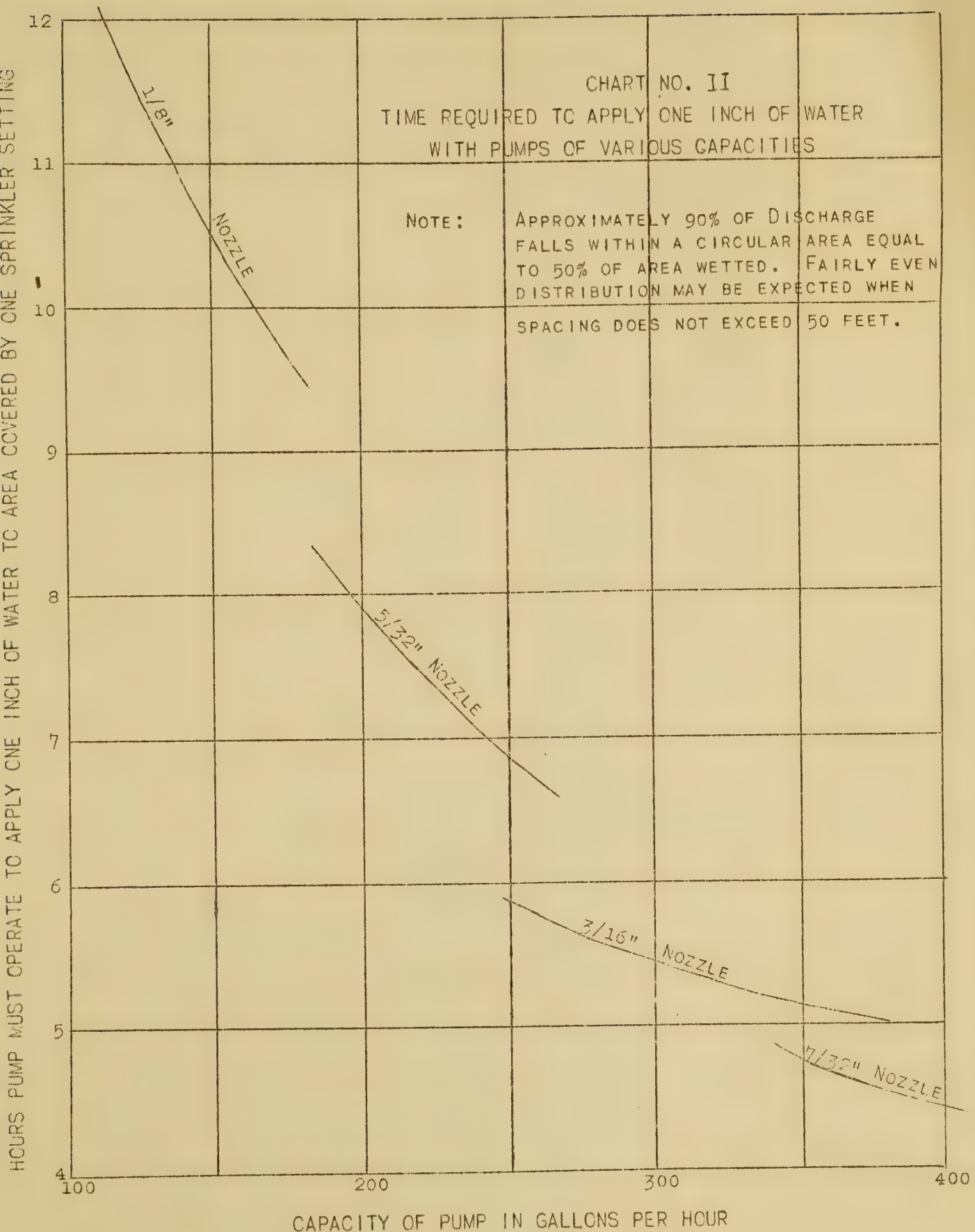


CHART NO. II
TIME REQUIRED TO APPLY ONE INCH OF WATER
WITH PUMPS OF VARIOUS CAPACITIES
NOTE: APPROXIMATELY 90% OF DISCHARGE FALLS WITHIN A CIRCULAR AREA EQUAL TO 50% OF AREA WETTED. FAIRLY EVEN DISTRIBUTION MAY BE EXPECTED WHEN SPACING DOES NOT EXCEED 50 FEET.
1/8" NOZZLE
5/32" NOZZLE
3/16" NOZZLE
7/32" NOZZLE
HOURS PUMP MUST OPERATE TO APPLY ONE INCH OF WATER TO AREA COVERED BY ONE SPRINKLER SETTING
12
11
10
9
8
7
6
5
4
100
200
300
400
CAPACITY OF PUMP IN GALLONS PER HOUR

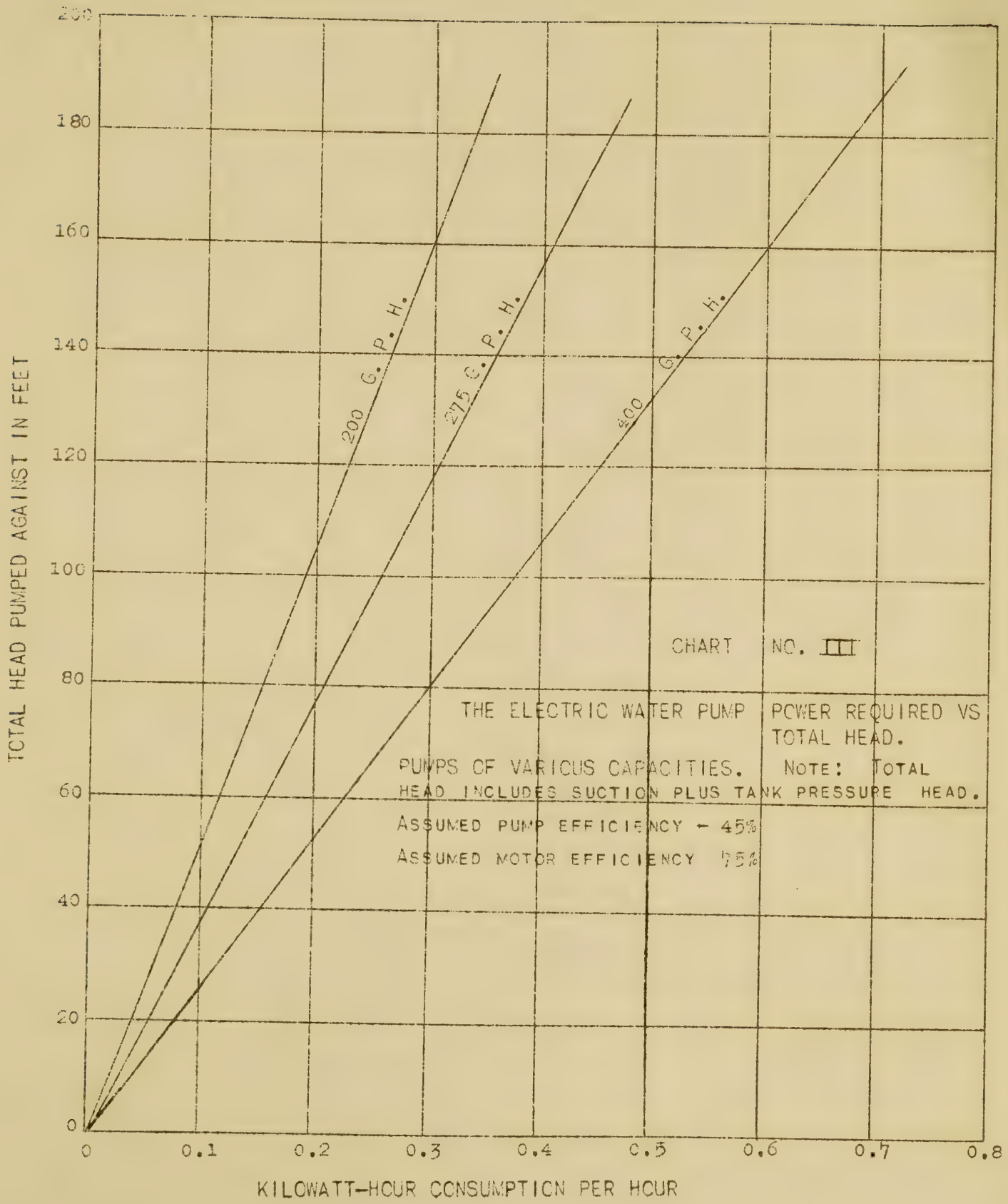

TOTAL HEAD PUMPED AGAINST IN FEET
200
180
160
140
120
100
80
60
40
20
0
200 G. P. H.
275 G. P. H.
400 G. P. H.
CHART NO. III
THE ELECTRIC WATER PUMP POWER REQUIRED VS TOTAL HEAD.
PUMPS OF VARICUS CAPACITIES. NOTE: TOTAL HEAD INCLUDES SUCTION PLUS TANK PRESSURE HEAD.
ASSUMED PUMP EFFICIENCY - 45%
ASSUMED MOTOR EFFICIENCY 75%
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
KILOWATT-HOUR CONSUMPTION PER HOUR

TABLE 1

Characteristic of Garden Sprinkler With
Nozzles of Various Sizes

Pressure	1/8" Nozzle			5/32" Nozzle			3/16" Nozzle			7/32" Nozzle		
	Diameter in ft.	Discharge in gph	Hours to apply one inch water	Diameter in ft.	Discharge in gph	Hours to apply one inch water	Diameter in ft.	Discharge in gph	Hours to apply one inch water	Diameter in ft.	Discharge in gph	Hours to apply one inch water
20	72	118	12¼	73	182	8¼	74	260	5¾	76	350	4¾
25	75	131	11¾	76	206	7¾	77	292	5½	79	390	4½
30	76	146	10¾	78	227	7¼	79	323	5¼	80	430	4¼
35	77	160	10¼	79	246	7	81	350	5¼	82	470	4
40	78	172	9¾	80	264	6¾	82	376	5	83	500	3¾

TABLE 2

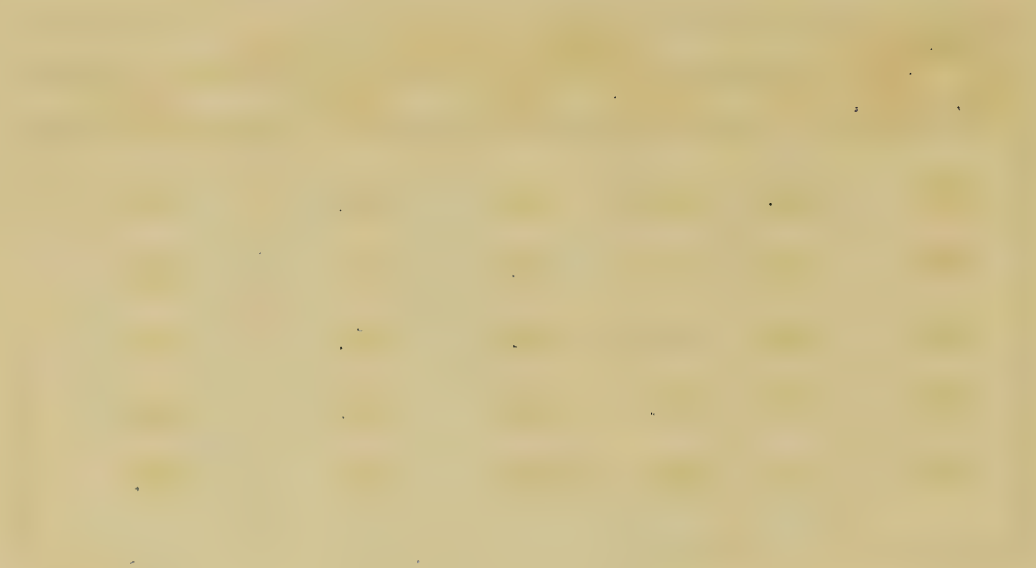
Pressure Drop in Pounds Per Square Inch
5/8" Garden Hose

Capacity of Pump G. P. H.	Lengths of Hose in Feet				
	50'	100'	150'	200'	250'
200	1.0	1.9	2.9	3.9	4.8
275	1.8	3.5	5.4	7.1	8.9
400	3.3	6.6	10.0	13.3	16.7
480	4.4	8.8	13.2	17.6	22.0
600	6.8	13.5	20.3	27.0	33.8

TABLE 3

Pressure Drop in Pounds Per Square Inch
3/4" Garden Hose

Capacity of Pump G. P. H.	Length of Hose in Feet				
	50'	100'	150'	200'	250'
200	0.5	1.0	1.5	2.1	2.6
275	0.9	1.8	2.7	3.6	4.5
400	1.9	3.7	5.6	7.4	9.3
480	2.5	5.0	7.5	10.0	12.5
600	4.2	8.3	12.5	16.7	20.8



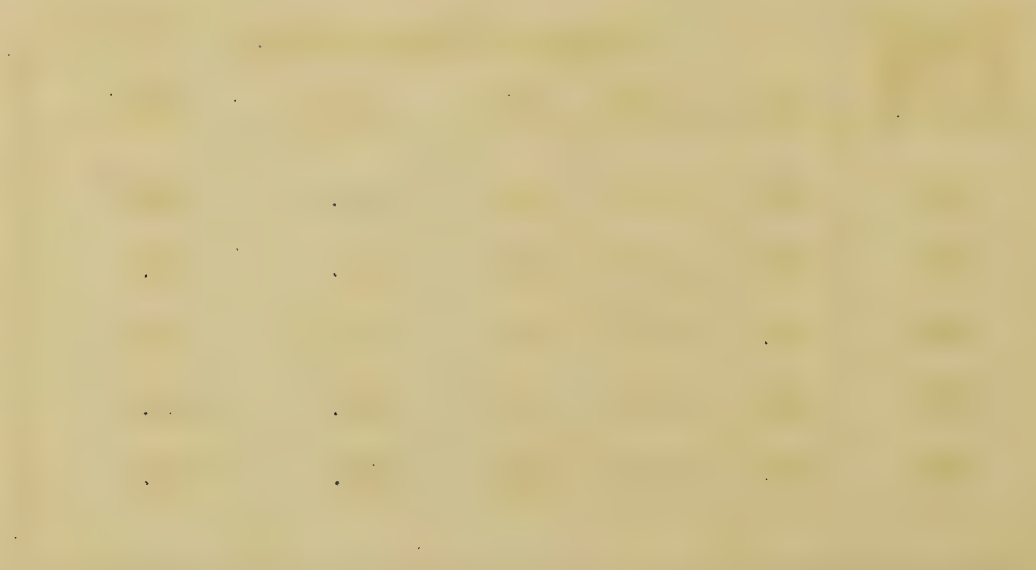


TABLE 4

Pressure Drop in Pounds Per Square Inch
1/2 Inch Iron Pipe

Capacity of Pump G. P. H.	Length of Pipe in Feet				
	50'	100'	150'	200'	250'
200	4.2	8.4	12.5	16.7	20.8
275	8.4	16.7	25.0	---	---
400	--	--	--	--	--

TABLE 5

Pressure Drop in Pounds Per Square Inch
3/4 Inch Iron Pipe

Capacity of Pump G. P. H.	Length of Pipe in Feet				
	50'	100'	150'	200'	250'
200	1.1	2.2	3.3	4.4	5.5
275	2.0	4.0	6.0	8.0	10.0
400	4.2	8.4	12.5	16.7	20.8
480	5.0	10.0	15.0	20.0	--
600	8.3	16.5	24.8	--	--

TABLE 6

Pressure Drop in Pounds Per Square Inch
1 Inch Iron Pipe

Capacity of Pump G. P. H.	Length of Pipe in Feet				
	50'	100'	150'	200'	250'
200	0.4	0.7	1.0	1.4	1.7
275	0.6	1.2	1.8	2.4	3.0
400	1.2	2.4	3.6	4.8	6.0
480	1.6	3.1	4.7	6.3	7.8
600	2.5	5.0	7.5	10.0	12.5

TABLE 7

Pressure Drop in Pounds Per Square Inch
1 1/4 Inch Iron Pipe

Capacity of Pump G. P. H.	Length of Pipe in Feet				
	50'	100'	150'	200'	250'
200	0.1	0.2	0.3	0.4	0.4
275	0.2	0.3	0.5	0.6	0.8
400	0.3	0.6	0.9	1.2	1.5
480	0.4	0.8	1.2	1.6	2.0
600	0.7	1.3	2.0	2.6	3.3

TABLE 8

Pressure Drop in Pounds Per Square Inch
In Various Pipe Fittings

Capacity of Pump G. P. H.	Size of Fitting			
	1/2"	3/4"	1"	$1\frac{1}{4}$"
		STANDARD TEE		
200	0.33	0.11	0.04	0.01
275	0.62	0.20	0.07	0.03
400	1.21	0.42	0.15	0.05
		STANDARD 90° ELBOW		
200	0.17	0.04	0.02	0.01
275	0.31	0.08	0.04	0.01
400	0.61	0.17	0.08	0.02
		45° ELBOW		
200	0.08	0.02	0.01	--
275	0.15	0.04	0.02	--
400	0.30	0.08	0.05	0.01
		FAUCET (ANGLE VALVE)		
200	0.75	0.26	0.10	0.03
275	1.39	0.48	0.18	0.06
400	2.70	1.00	0.39	0.11

EXAMPLE I

Pump Capacity	200 GPH
Distance of sprinkler setting from house	150 ft.
Inside piping, pump to faucet (3/4")	20 ft.
Pipe fittings (assumed)	
faucets	1
90" standard elbows	4
tees	1

Size of Sprinkler Nozzle (Chart No. I)

Size of nozzle required	5/32 inch
Pressure at Sprinkler	23 lb/ sq. in.

Pressure Drop (Tables 2-8, inclusive)

Pressure at Sprinkler		23 lb/ sq. in.
Loss in 150 ft. of 5/8" hose	2.90 lb/ sq. in.	
Loss in 20 ft. of 3/4" pipe	.44	
Loss in fittings:		
faucet (3/4")	.26	
tee (3/4")	.11	
elbows (3/4")4x.04 =	.16	
Total pressure drop		3.87
Pressure at pump		26.87 lb/ sq. in.

Applying One Inch of Water (Chart No. II)

Time required	8 hours

Power Requirements (Chart No. III)

Pressure Head	26.87 x 2.31	62 ft.
Lift (assumed)		80 ft.
Total head pumped against		142 feet
Energy required		0.26 kwh/hr
Cost of energy		3 c/kwh
Cost of operating pump		0.78 c/hr

EXAMPLE II

Pump Capacity		275 G.P.H.
Distance of sprinkler setting from house		150
Inside Piping, pump to faucet (3/4")		20
Pipe fittings		
faucet		1
tee		1
elbow (90°) (standard)		4

Size of Sprinkler Nozzle (Chart I)

Size of nozzle required	3/16"
Pressure at sprinkler	22.5 lb/sq.in.

Pressure Drop (Tables 2-8, inclusive)

Pressure at Sprinkler		22.50 lb/sq.in.
Loss in 150 ft. of 3/4" hose	2.7 lb/sq.in.	
Loss in 20 ft. of 3/4" pipe	.80	
Loss in fittings		
faucet (3/4")	.48	
tee (3/4")	.20	
elbows (4-3/4")	.32	
Total pressure drop		4.5
Pressure at pump		27.00 lb/sq.in.

Applying One Inch of Water (Chart No. II)

Time Required -- one sprinkler setting	5.7 hours

Power Requirements (Chart No. III)

Pressure head 27.0 x 2.31	60 ft.		
Lift (assumed)	95 ft.		
Total head pumped against		155	ft.
Energy required		0.39	kwh/hr.
Cost of energy		3	c/kwh
Cost of operating pump		1.17	c/hr.

EXAMPLE 3-A

Single Sprinkler

Pump Capacity	400 G.P.H.
Distance of Sprinkler from house	150 ft.
Inside Piping, pump to faucet (3/4")	20 ft.
Pipe fittings (assumed)	
faucets	1
tees	1
elbows (90° standard)	4

Size of Sprinkler Nozzle (Chart No. I)

Size of Nozzle required	7/32"
Pressure at sprinkler	26.70 lb/sq.in.

Pressure Drop (Tables 2-8, inclusive)

Solution 1

Pressure at sprinkler		26.70 lb/sq.in.
Loss in 150 ft. of 3/4" hose	5.60 lb/sq.in.	
Loss in 20 ft. of 3/4" pipe	1.70	
Loss in fittings:		
faucet (3/4")	1.00	
tee (3/4")	.42	
elbows (4-3/4")	.68	
Total pressure drop		9.40
Pressure at pump		36.10 lb/sq.in.

Pressure Drop (Tables 2-8, inclusive)

Solution 2

Pressure at sprinkler		26.70 lb/sq.in.
Loss in 100 ft. of 1" pipe	2.4 lb/sq.in.	
Loss in 50 ft. of 3/4" hose	1.9	
Loss in 20 ft. of 3/4" pipe	1.9	
Loss in fittings:		
faucet (3/4")	1.0	
tee (3/4")	.42	
elbows (4-3/4")	.68	
Total pressure drop		8.10
Pressure at pump		34.80 lb/sq.in.

Pressure Drop (Tables 2-8, inclusive)

Solution 3 (connect 3/4" hose at pump)

Pressure at sprinkler	26.70 lb/sq.in.
Loss in 200 feet of 3/4" hose	7.40
Pressure at pump	34.10 lb/sq.in.

Applying One Inch of Water (Chart No. II)

Time required, one sprinkler setting	4.5 hours

Power Requirements (Chart No. III)

Pressure head 36.10 x 2.31	83 feet
Lift (assumed	56 feet
Total head pumped against	139 feet
Energy required	0.52 kwh/hr.
Cost of energy	3 ¢/kwh
Cost of operating power	1.56¢/hr.

EXAMPLE 3-B

Two Sprinklers in Series

Pump Capacity	400 G. P.
Sprinkler discharge, each	200 G. P.
Distance of sprinkler from house	150 ft.
Inside piping, pump to faucet (3/4")	20 ft.
Pipe fittings (assumed)	
faucets	1
tees	1
elbows (90° standard)	4

Size of Sprinkler Nozzle (Chart No. 1)

Size of nozzle required	5/32 in.
Pressure at sprinklers	23 lb/sq.

Pressure drop (Tables 2-8, inclusive)

Pressure at sprinklers	23 lb/sq.
Pressure drop between sprinklers 1 and 2	
Loss in 50 ft. of 3/4" hose (200 gph)	0.50 lb/s
Pressure drop between pump and No. 1 sprinkler	
Loss in 100 ft. of 3/4" hose (400 gph)	3.80
Loss in 20 ft. of 3/4" pipe	1.70
Loss in fittings	
faucet (3/4")	1.00
tee (3/4")	0.42
elbows (4-3/4")	0.68
Total pressure drop	8.10
Pressure at pump	31.10 lb/s

Applying One Inch of Water (Chart No. II)

Time required	8 hour

Power Requirements (Chart No. III)

Pressure head (31.10 x 2.31)	72 ft.
Lift (assumed)	80 ft.
Total head pumped against	152 ft.
Energy required	0.58 kwh/
Energy cost	3 ¢/kw
Cost of operating pump	1.74 ¢ hr

SUMMARY

On the basis of the examples, charts, and tables, the following summary briefly sets forth the conditions under which the sprinkler and automatic water system will perform satisfactorily:

1. When the pump capacity is approximately 200 gallons per hour
   a. One sprinkler equipped with a 5/32" nozzle should be used.
   b. If the distance of sprinkler setting from the pump or house faucet does not exceed 300 feet, 5/8" hose can be safely and satisfactorily used.
   c. Operate 8 hours to apply one inch of water to area effectively covered by sprinkler.
2. When the pump capacity is approximately 275 gallons per hour
   a. One sprinkler, equipped with 3/16" nozzle, should be used.
   b. If the distance of the sprinkler setting from the pump or house faucet
      (1) does not exceed 150 feet, 5/8" hose can be used.
      (2) does not exceed 300 feet, 3/4" hose can be used.
      (3) does exceed 300 feet, a combination of hose and 1" or $1\frac{1}{4}$" pipe should be used.
   c. Operate from $5\frac{1}{2}$ to 6 hours in one setting to apply one inch of water.
3. When the pump capacity is approximately 400 gallons per hour:
   a. Use one sprinkler equipped with a 7/32" nozzle, or use two sprinklers equipped with 5/32" nozzles.
   b. If the distance of the sprinkler setting from the pump or house faucet
      (1) does not exceed 200 feet, 3/4" hose can be used.
      (2) does exceed 200 feet, a combination of hose and 1" or $1\frac{1}{4}$" pipe should be used.
   c. To apply one inch of water to the area effectively covered in one sprinkler setting,
      (1) operate approximately $4\frac{1}{2}$ hours with one sprinkler.
      (2) operate approximately 8 hours when using two sprinklers in series.

A GARDEN IRRIGATION UNIT

FIGURE 1